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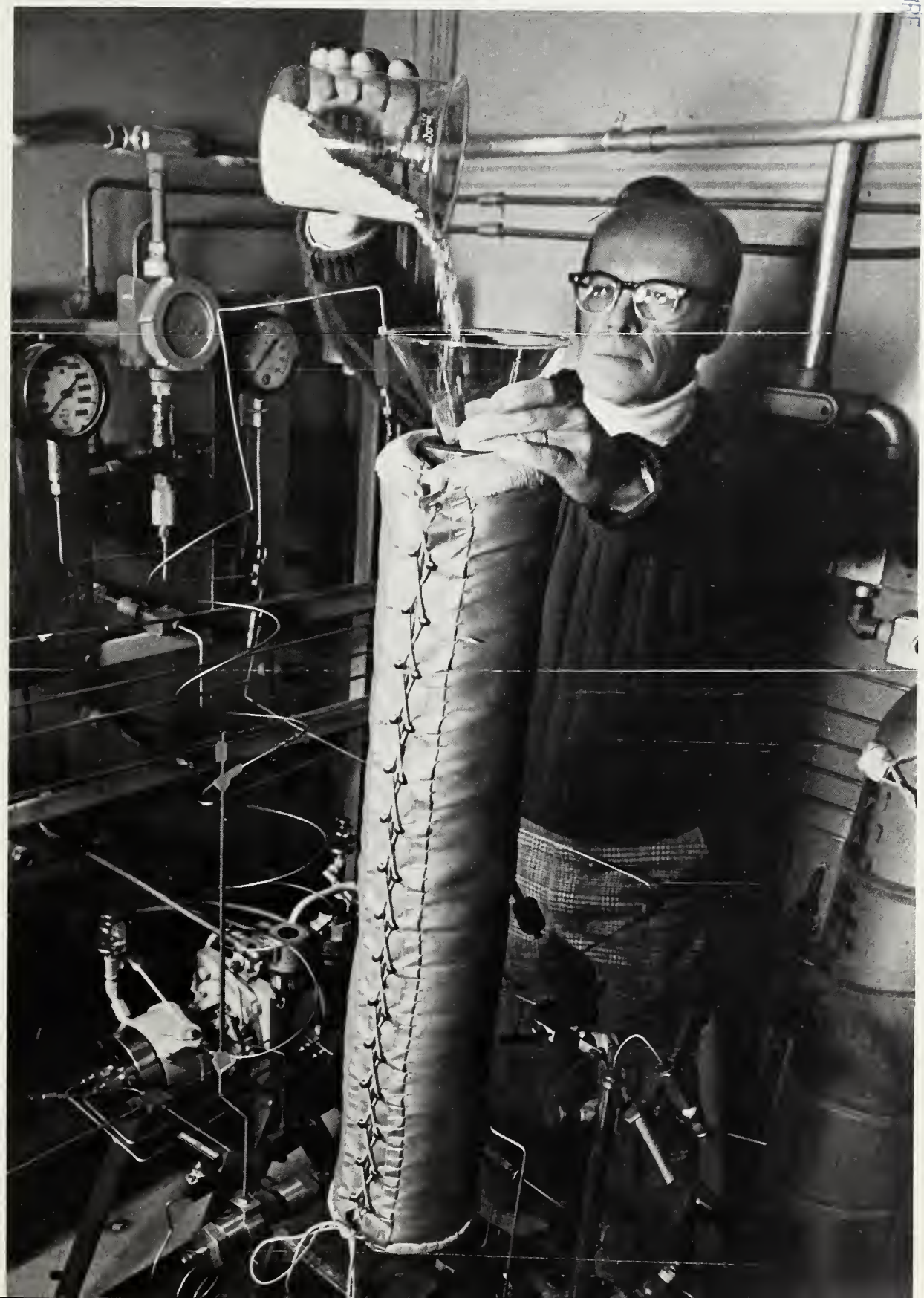

USDA Patents— From Research to Users

"Technology transfer" is a phrase much bandied about. To those of us in agricultural research it means getting the results of vital research out of the laboratory and to the users—farmers, ranchers, soil conservationists, Extension staff, and others who work within our agricultural system.

From the beginning of USDA, new scientific, chemical, and technical uses for farm products and for expanding their markets and outlets have come from agricultural research.

ARS encourages its scientists to patent their research results, which puts the Government-patented technology in the public domain. For the last 40 years, USDA has encouraged the public to license these patents on a nonexclusive basis. By obtaining licenses, individuals and industry may use USDA technology in developing and marketing products commercially. Licensing is one of USDA's efforts to speed up the technology transfer process.

Until last July, patents were available to users only on a nonexclusive basis. This meant that no one could exclusively manufacture and sell products resulting from Government-funded technology.

Relatively few (about 30 percent of 1,200) patented ARS inventions have been licensed nonexclusively—simply because potential companies and individuals are reluctant to invest capital to develop and manufacture a product that others could also manufacture and sell. They would rather gamble on their own exclusive research developments.

Yet, some ARS inventions such as Super Slurper and the ropewick applicator for herbicides have made money for nonexclusive licensees and have had substantial impact on U.S. industries. Super Slurper, an absorbent made from corn starch, has helped the medical, chemical, seed, fertilizer, petroleum, and landscaping industries. Over 42 nonexclusive licenses have been granted on Super Slurper alone. At least 30 licenses have been granted for the ropewick applicator.

A number of products and technologies invented and patented by ARS scientists have substantially changed the market place. Among these are the commercial production of penicillin, fresh frozen orange juice concentrate, glutaraldehyde tanning of leather, flame-retardant fabric finishes, and potato flakes—just to mention a few.

Many more worthwhile patented inventions sit undeveloped, awaiting commercialization.

Last July, a new law became effective that allows private industry to obtain exclusive licenses to develop and market Government-funded technology. Its purpose was threefold—to ensure that this valuable resource was not wasted, to help reverse a recent trend of decreasing numbers of U.S. inventions, and to help our ailing economy get back on track by encouraging industry to invest in new technology.

So far, this new law is having its intended effect. Since July, 12 companies have applied for exclusive licenses. A few exclusive licenses have already been granted, and others will be soon.

Generally, licenses are granted nonexclusively. However, an exclusive license is granted if USDA determines it will best serve the public and if an incentive is needed to promote the practical commercial application of the patented technology in the shortest possible time.

And the future of ARS technology transfer looks even brighter—now that the new legislation stimulates the use of research findings on a commercial basis.

Whether the inventions are exclusive or not, licensees have regularly called upon ARS for technical advice. Its scientific staff often assists industry and individuals in adapting new and improved technology so it can get to the marketplace as quickly as possible. This is what technology transfer is all about.

While nonexclusive licenses are free, the cost to users for exclusive licenses ranges from a few hundred to a few thousand dollars—depending on the stage of development of the technology and on the anticipated market. These fees are insignificant when compared to the cost of human resources used in developing this technology and the loss to the American public if the technology sits unused.

Although there are risks to users, the benefits both to them and to the public are inestimable—maintaining the highest standard of living in the world through technology, America's most unique and renewable resource.

Contents

Agricultural Research
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Cover: Using CO_2 as the solvent, and high pressure equipment as the key, researchers have discovered an extraction method that could revolutionize oilseed processing. Project leader John P. Friedrich, research chemist, Northern Regional Research Center, loads a high pressure column with flaked oilseed to begin oil extraction. Article begins on page 8. (0182X015-16)

Hail Increases Prickly Pear

Hail, capable of completely ruining farmers' crops, benefits at least one plant—the prickly-pear cactus. The destructive ice pellets break off segments (or pads) from cactus on Great Plains rangeland. After a while, these segments root and become separate cactus plants.

While ranchers may find this a remarkable example of plant adaptation, they don't find it very good for their rangelands. Any weed that invades or spreads on a range reduces the amount of feed available to livestock.

ARS range scientist William A. Laycock studied cactus on two pastures after a July 1978 hailstorm at the Central Plains Experimental Range in northeastern Colorado. One pasture had about 1.3 percent of its ground covered with prickly-pear cactus. The second pasture had an average of 2.8 percent covered. After the severe storm, hail had knocked off about 1,600 cactus pads per acre in the first pasture and about 7,700 pads per acre in the second pasture.

One year later, 34 percent of the pads had rooted in the first pasture and 13 percent in the second pasture. This resulted in an average 560 new cactus plants per acre in the first pasture and 960 plants in the second pasture. Both pastures had an area fenced to prevent cattle grazing, but fencing did not affect the number of new cactus plants. The pastures were on a sandy loam soil that is common over much of the Great Plains.

"When pads are broken off from the 'mother' plants, they are pretty well equipped to withstand harsh climatic conditions," says Laycock. "For 9 months after the storm, the pastures received less than 4 inches of precipitation. When we checked in March, none of the broken-off pads had developed roots into the soil. In May and June, the area received about 8 inches of rain and the next time we checked, in August, 1 year after the storm, we found the pads growing on their own. This remarkable adaptivity may be one of the reasons why prickly pear is so prevalent and persistent on the Plains."

Hail did not appear to cause any long-lasting damage to the existing cactus, but insects and disease could enter wounds created where hail had knocked off pads.

Even if it has been lying on the dry ground for months, a prickly-pear pad will root and grow after a good rain. (0981X1099-31)

William Laycock is located at the Crops Research Laboratory, Colorado State University, Fort Collins, CO 80523.—(By Dennis Senft, Oakland, Calif.)

Cactus Harvester

A cactus harvester, now in the development stage, might some day help ranchers improve their ranges while providing supplemental or emergency feed for cattle. Large populations of prickly-pear cactus lower the value and animal-carrying capacity of rangelands. Ironically, once the spines are removed, the cactus can be used for a supplemental or emergency feed. Cattlemen have been feeding prickly pear for more than a century, but the practice is limited because of the labor required to harvest and singe off the spines.

An estimated 79 million acres of rangeland, from Canada to Mexico, are infested with prickly-pear cactus.

The harvester is basically a farm tractor with a front-mounted, side-delivery rake and a side-mounted collector-singer. As the machine moves across a range, the specially designed teeth of the rake uproot cactus and deposit it in a windrow that the collector picks up.

The rake is not rigidly attached to the tractor. It is supported by its own wheels, which permits a close contact with the changing ground contour. Hydraulics, rather than direct gear drive, allow for variable speed on rake bars. If cactus populations are thick, the operator can speed the rake's revolutions without downshifting the tractor.

The collector has a pickup unit that elevates the cactus onto an apron of metal rods that moves them to a holding bin. The apron is metal so that burners can be installed underneath to singe the cactus as it moves up the conveyor. Burner installation is the next development stage.

"In 1980, the harvester reduced prickly-pear biomass an average of 86 percent under moist soil conditions. In 1981, the harvester reduced cactus biomass an average of 92 percent under dry soil conditions. I believe this 6-percent improvement is due mostly to modifications we made to the machine during the winter of 1980-81," says ARS range scientist Dennis M. Mueller.

"Previous research conducted at the Central Plains Experimental Range near Nunn, Colo., showed that heifers fed singed prickly-pear cactus as a supplement to hay gained an average of 1½ pounds daily. Heifers fed only the amount of hay that would furnish the nutrition ordinarily received on a winter range gained less than 1 pound per day," says ARS range scientist Marvin C. Shoop.

Dennis Mueller and Marvin Shoop are located at the Crops Research Laboratory, Colorado State University, Fort Collins, CO 80523.—(By Dennis Senft, Oakland, Calif.)

Above: The cactus harvester rakes up and delivers cactus to the collector-conveyor on the left. The enclosure on the front keeps the rake from flinging plants out onto the ground, where they would propagate. (0981X1098-30)

Left: These specially designed rake teeth uproot the cactus as the harvester moves across the range. (0981X1100-34)

Uncommon Uses for Common Okra

Okra used as a "spinach," a coffee substitute, or hydrogenated for use in margarine? These are real possibilities, says ARS horticulturist Franklin W. Martin.

Okra is a hot weather crop of the temperate zone and the tropics. Most U.S. consumers know it best cut up in southern gumbo, deep fried, or steamed whole as "baby okra."

In Africa, Asia, and Latin America, which comprise three-fourths of the world's population, okra is often used as a vegetable.

But Martin, at the Mayaguez Institute of Tropical Agriculture in Puerto Rico, takes this controversial plant (some people love its flavor, some hate its texture) many steps further.

"Recent findings show that the okra plant can be used for several purposes, some still in the area of speculation, others already of proven value," he says.

The proof is indeed mixed with speculation, but caution tempers Martin's speculations.

The proof:

- In West Africa and Southeast Asia, okra is a leaf vegetable cooked like spinach. It is high in vitamins A and C, protein, calcium, and iron.
- Mature okra pods can be cooked for their seeds; after cooking, the tender seeds are extracted and used in place of legumes.
- Mature dried seeds of okra are roasted and ground as a coffee substitute or added to coffee. In El Salvador and Malaysia, people wake up to caffeine-free okra coffee, said to have a good aroma. Okra's presence as an adulterant in regular coffee is said to be hard to detect.
- Okra seed oil is highly suitable as an edible fat. The unsaturated fatty acids, linoleic and oleic, are high—70 percent. The oil is readily hydrogenated for use as solid shortening and could be used in margarine.
- The protein content of okra seed ranges from 15 to 26 percent. One advantage of okra seed as a source of both oil and protein is the ease of preparation, says Martin. He and agricultural technicial Ruth Ruberte used a hand mill and sieves in 1979 to separate a high-protein, high-oil meal from the hull, and showed the usefulness of this meal in baked products.

The speculation:

- Okra seed can be used to make a vegetable curd, something like soybean tofu. Protein and oil can be separated from the hulls by grinding the seeds finely in water and straining the mixture through a cloth filter. The protein is separated from the oil and used fresh or cooked as a cheese substitute. The vegetable curd was pronounced pleasant by a taste panel in Puerto Rico.
- According to Martin, the fiber of the okra plant is a good material for making paper. The large-stalked, rapidly growing West African varieties that cannot flower in the continental United States have been investigated as a source for pulp production. However, the Asian plant ramie, with its strong woody fiber, is a better source than okra.
- Martin suggests that the mucilage of immature okra, easily obtained when slices are placed in water, be used to size paper, as it is in Malaysia. It is also potentially useful as an extender of serum albumin and as an egg white extender or substitute.
- Thoroughly dried okra stalks can be burned as an inexpensive source of fuel on the farm, although there are more efficient fuel producers.

However, okra vegetable curd may be a questionable food source. To avoid possible long-term toxicity, it would be desirable to remove the gossypol from the ground seed. Gossypol is a pigment toxic to some animals and to humans. However, in cottonseed oil, gossypol is removed with a butanol solution, and Martin urges a comparable treatment for okra seed as one alternative. But Martin adds that in 100 varieties of okra tested, the amount of gossypol was less (from unmeasured

(Photo courtesy of Grant Heilman.)

lows to a high of 290 parts per million) than that regarded as safe in cottonseed meal.

"It is possible that gossypol in okra seed will limit the use of the seed as a feed or food unless the gossypol is removed or detoxified, as in cottonseed, or unless okra seed free of gossypol is developed. A certain amount of it can be tolerated in the diet," he says. The U.S. Food and Drug Administration permits up to 450 ppm in edible cottonseed flour.

The strong possibility that gossypol in okra seed can be eliminated by breeding merits attention. Martin notes that glandless (gossypol-free) cottonseed has already been tested in the United States for use in breads and is a promising foodstuff.

Franklin W. Martin is located at the Mayaguez Institute of Tropical Agriculture, P.O. Box 70, Mayaguez, PR 00708.—(By Peggy Goodin, New Orleans, La.)

Suppressing Bollworms by Mowing

Mowing less than 5 percent of the total rural area in the Delta of Mississippi twice in spring may significantly reduce later buildup of bollworm and tobacco budworm populations in cotton.

According to ARS entomologist Earl Stadelbacher, mowing the borders of cultivated fields and the shoulders of roads in the Delta of Mississippi during late April and mid-May will destroy a high percentage of the first generation of these two insect pests.

Adults emerge in spring from the overwintered pupal populations about 1½ months before cotton is available. During this period these adults and their F_1 larval generation (first generation progeny) depend on wild host plants for survival and population buildup. In early June the F_1 adults emerge, migrate into cotton fields, and produce the initial bollworm-tobacco budworm larval infestations.

"Results of research in 1980," says Stadelbacher, "indicate that the mowing method of cultural control, if applied over a wide area, could be the first step in an annual integrated pest management system. Mowing is relatively inexpensive compared to the present methods of insect control, which require several applications of insecticides on thousands of acres of cotton. Moreover, mowing may also work well with early season releases of parasites of the bollworm and tobacco budworm, which would complement the mowing technique by ensuring treatment of the small percentage of the area inaccessible to mowing." Because only a small acreage is inaccessible to mowing, the numbers of parasites needed in an early season release would be much smaller than the number needed if the releases were made later, after thousands of acres of cotton were infested.

The scientist explained that egg parasites of the pests are extremely sensitive to insecticides. If they are released in early season in conjunction with mowing, however, the parasite would be released 1 to 1½ months before insecticides are applied. Mowing could also reduce the use of insecticides and thus be both environmentally and economically beneficial. Early season suppression of the pests by mowing their wild host plants could delay or even prevent large, costly buildups of the bollworm and tobacco budworm on cultivated crops later in the season.

Stadelbacher is continuing his research to refine the mowing technique, which he says can be of significant benefit to cotton producers.

Stadelbacher is located at the Bioenvironmental Insect Control Laboratory, P.O. Box 225, Stoneville, MS 38776.—(By Bennett Carriere, New Orleans, La.)

Carbon Dioxide Extracts Seed Oils

The common gas carbon dioxide (CO_2) is being made to act like a liquid that could spell long-run cost savings and purer oil extracts for the oilseed industry. When CO_2 is heated at high pressure, it takes on new properties capable of separating unlike materials, such as oil and protein.

ARS chemist John P. Friedrich, along with other scientists at the Northern Regional Research Center (NRRC), Peoria, Ill., is studying the intricacies of using liquidlike CO_2 to replace the petroleum solvent hexane, now widely used in extracting oil from many kinds of seeds.

As a solvent, CO_2 dissolves oil and flushes it out of crushed flaked soybeans, corn germ, and other seed material, acting much like water does in making coffee from grounds or tea from leaves.

Supercritical CO_2 could be used in numerous processes. An indication of its potential is found in inquiries to NRRC scientists:

An American corn miller, writing specifications for a processing plant, is looking for help in using CO_2 to extract food oil from corn germ to make high protein flour. . .

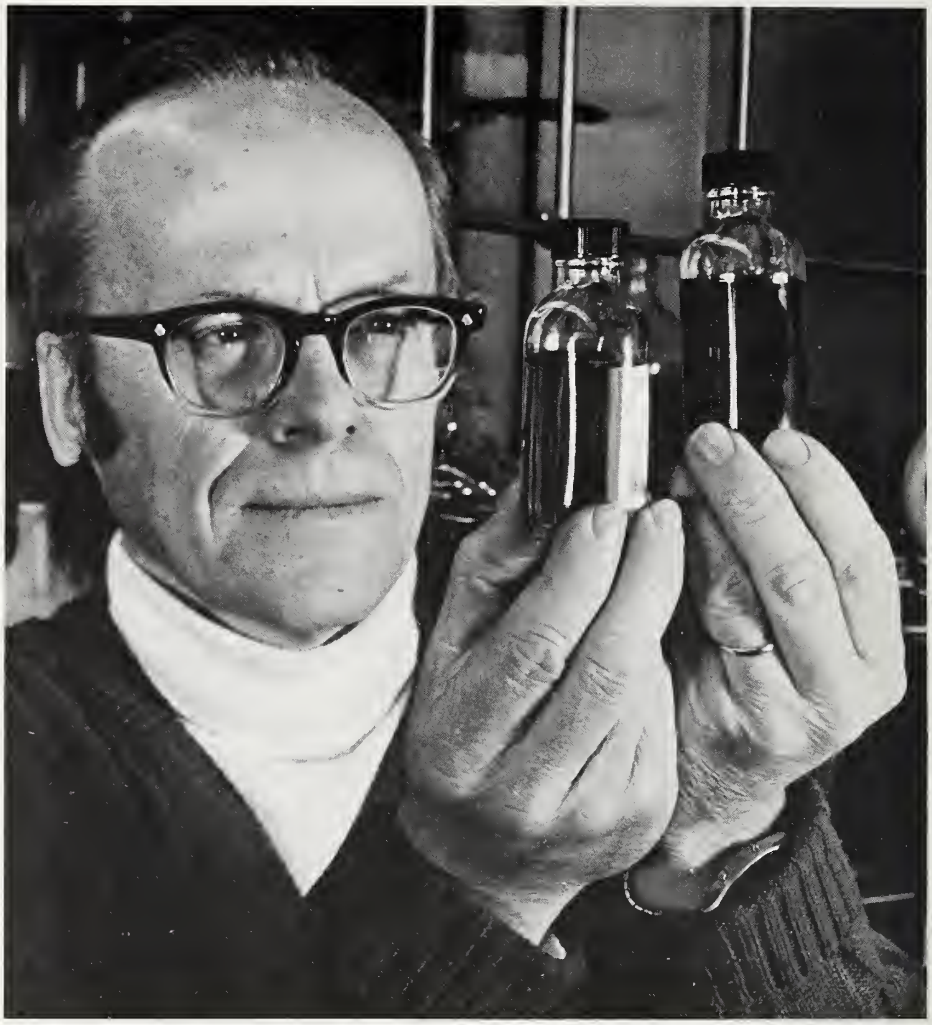
A Mexican company is seeking to extract oil from avocados. . .

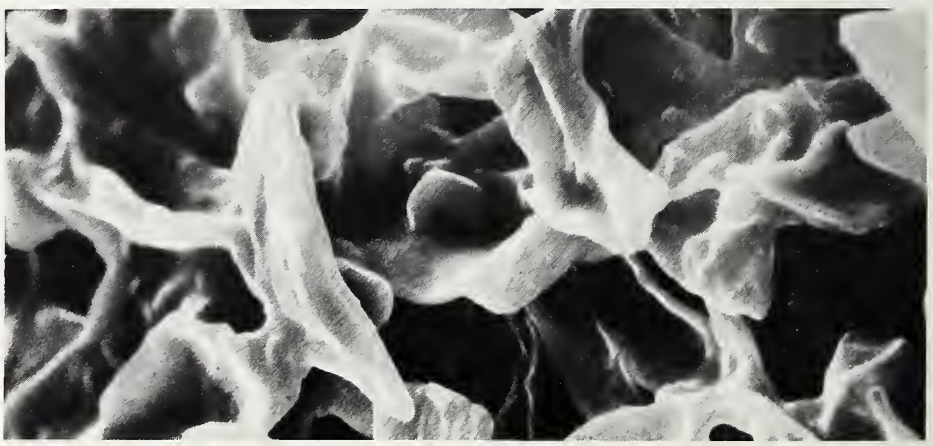
A Canadian food oil processor wants to try CO_2 extraction of sunflower oil and of canola, a special kind of rapeseed oil. . .

And, an American firm wants to know about refining soy gum, or lecithin, for food.

They and other food and vegetable oil processors and grain millers in the United States and 15 foreign countries are among companies asking for details about this basic research.

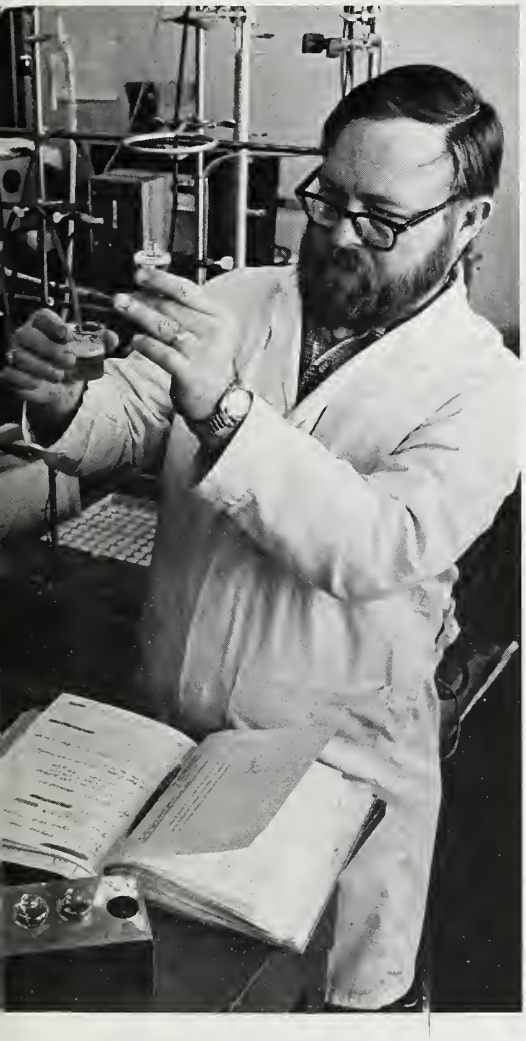
Millers are interested in extracting bitter components from sorghum germ, wax from sorghum bran, and oil and protein from wheat germ. Food company scientists want to extract spices, remove oil from snack foods, and get oil and protein from cottonseed, corn, soybeans, and wheat.





Above: Research chemist John P. Friedrich compares dark hexane-extracted corn oil (right) with the purer, lighter colored oil extracted using the new CO_2 process. (0182X020-6)

Below: Shrunken oil sacs from corn germ, greatly magnified in this scanning electron micrograph, remain after the CO_2 extraction process. (PN-6843)



Above: Research chemist Gary R. List compares the gum content of oils extracted with hexane and CO_2. (0182X018-8)

In the NRRC studies, hexane is replaced by CO_2 at 8000 pounds pressure per square inch and 50° C (122° F).

Friedrich explains that when CO_2 is under high pressure and above its critical temperature, 31° C, it cannot be compressed to a liquid. This supercritical CO_2 takes on the density of a liquid, he says, "but it is still a gas and so can diffuse easily through a bed of flaked soybeans or corn germ.

"The phenomena of supercritical fluid extraction were observed more than 100 years ago," Friedrich says, "but the technology has been slow to find commercial application, due in part to the sophisticated and expensive high pressure equipment required."

"The use of supercritical CO_2 could revolutionize the oilseeds industry," says Timothy L. Mounts, oilseeds research chief, "if the advantages found in our basic research appear to justify the costs of complete retooling."

Use of CO_2 could offer long-range cost and availability advantages. The chief operating cost would be for the compression, and Friedrich says compressed CO_2 can be recycled at constant pressure, thereby reducing this cost.

He points out that much of the petroleum from which hexane is produced is from foreign sources and could be cut off. The cost of hexane, furthermore, has increased from 14 cents to about $1.40 a gallon in less than 10 years, even faster than the cost of gasoline.

Friedrich says oilseeds processors lose about 20 million gallons of hexane each year in extracting a billion bushels of soybeans.

NRRC scientists designed and built equipment for the CO_2 research. As project leader, Friedrich adapted facilities and equipment developed earlier for high-pressure reactions such as hydrogenating soybean oil for food and reacting vegetable oils with carbon monoxide and hydrogen to replace petroleum-based products. Between them, Friedrich and Research Leader Edwin N. Frankel have more than 40 years' experience in research on high-pressure reactions of vegetable oils.

In the new studies, Friedrich, ARS research chemist Gary R. List, and technican Allen J. Heaken found that supercritical CO_2 absorbs 2.5 to 2.7 percent of its own weight of soybean oil and removes it from the flakes. "The oil is separated from the CO_2 simply by reducing the pressure or increasing the temperature," Friedrich says. "This reduces the holding capacity of the CO_2, and the oil falls out." The process gives oil yields comparable to, and quality better than, those from extracting with flammable hexane.

The main difference between soy oils extracted with CO_2 and those extracted with hexane is a phosphorus-based gum, lecithin. Friedrich says hexane-extracted oil contains 500 to 700 parts of phosphorus per million parts of oil, more than 10 times the phosphorus in CO_2-extracted oil. Degumming, an extra processing step, is required after hexane extraction to produce food-quality soybean oil.

"Oil obtained with supercritical CO_2," Friedrich says, "has the advantage of being essentially equivalent to a degummed hexane crude."

In extracting oil from both wet- and dry-milled corn germ with CO_2, Friedrich and ARS chemist Donald D. Christianson find that overall quality of both the oil and corn germ flour are equal to or better than the hexane-extracted food products.

"The free fatty acid content in CO_2-extracted flours is tenfold less than in hexane-extracted flours," Christianson says.

Taste panel tests of wet-milled corn germ flour, conducted by Kathleen A. Warner at the NRRC, show that the flour processed at 24 percent moisture is comparable in flavor to wheat flour.

Friedrich, Christianson, and Warner are conducting the corn germ extraction studies with Edward B. Bagley and George E. Inglett, cereals scientists. In the studies, moisture content of corn germ flour is reduced to less than 3 percent, which makes the flour more friable. The oil is clearer and lighter colored than hexane-extracted oil.

All in all, Friedrich says, based on the research and commercial inquiries, it appears that supercritical CO_2 offers promise in saving petroleum and lowering the costs of extracting the oil from oilseed crops.

John P. Friedrich is located at the Northern Regional Research Center, 1815 N. University St., Peoria, IL 61604.

Biocontrol of Malaria-Carrying Mosquitoes

Biological control of insects seldom affects people more than when it is directed at disease-bearing mosquitoes.

Research entomologists have found that parasitic wormlike nematodes are an alternative to chemical insecticides in mosquito control.

At the Gulf Coast Mosquito Research Laboratory, cultures of the mermithid nematode *Romanomermis culicivorax* were produced and shipped air freight to El Salvador, where they were released in typical breeding sites of the malaria-carrying mosquito, *Anopheles albimanus*.

Malaria, once nearly eradicated worldwide, is now on the upsurge. By 1978, malaria cases reached 150 million in Asia and Central and South America, and the disease is unchecked in Africa, where at least a million children under age 14 die from it every year. Some mosquitoes have developed resistance to pesticides, and the parasites they carry outwit antimalaria drugs.

Twenty-two mosquito-breeding sites were treated in El Salvador with the nematode *Romanomermis culicivorax* at dosages ranging from 2,400 to 4,800 infective parasites per square meter of surface water. Treated areas were flooded pastures, roadside ditches, ponds, and swamps containing larval populations of *An. albimanus*.

In a second test, the breeding margin of Lake Apastepeque in inland El Salvador was treated twice at a rate of 3,600 infective parasites per square meter of surface area.

All treatments gave excellent parasitism of the anopheles mosquito, regardless of dosage or the age of the larvae, say the scientists. The parasitism was lethal, and multiple parasitism of larvae was common. Overall parasitism for the treatments averaged 96 percent, and mean parasitism for the first to fourth stages of larval development was 95, 95, 98, and 95 percent. Occasionally larvae of the mosquitoes *Uranotaenia lowii* and *Culex erraticus* were present and infected.

The two early evening treatments of Lake Apastepeque in November 1977 produced an average parasitism of 96 percent. "When this figure is combined with the figure for three early evening treatments of the lake during a previous study in March 1977, 92 percent of the larval populations of *An. albimanus* and *An. pseudopunctipennis pseudopunctipennis* were parasitized," says entomologist Osborne R. Willis. "This is much higher than the 58 percent parasitism achieved during 11 treatments in early 1977, and exactly double the 46 percent parasitism for the eight midday treatments made during the same study."

The scientists' consensus was that the nematode *Romanomermis culicivorax* was extremely effective against all stages of anopheline larvae that were present in many kinds of freshwater habitats.

According to entomologist and research leader Edwin I. Hazard, the Gulf Coast Mosquito Research Laboratory continues to mass culture *Romanomermis culicivorax* for research studies and field tests conducted by scientists in countries having serious problems with disease-carrying mosquitoes.

Osborne R. Willis, Harold Chapman (former Director, now serving as research consultant) and James J. Petersen (currently with the ARS Livestock Insect Research Unit at the University of Nebraska) reported the successful study at the Gulf Coast Mosquito Laboratory, 803 Avenue J. and Chennault, Lake Charles, LA 70601.—(By Peggy Goodin, New Orleans, La.)

Date Palm Tissue—from Deep Freeze to Plantlets

Tissue cultures of date palm trees—callus material containing all the genetic "information" necessary for the cloning of date trees—have been successfully frozen to -321°F, thawed, and grown into plantlets.

The finding makes possible frozen germplasm banks where all the known desirable varieties of date palm genetic material could be saved in "test tubes" and preserved for future breeding work. Now it takes several acres of land to preserve only a few palm tree varieties. Seeds are unreliable because they do not breed "true."

Brent Tisserat, ARS plant geneticist, Pasadena, Calif., says it is the first time that trees have been successfully preserved by cryogenic storage. This finding, he says, might make possible the frozen storage of other types of valuable fruit tree germplasm—those, at least, that can be successfully propagated by tissue culture.

Tisserat had earlier perfected the technique of cloning date palm trees from tissue culture he obtained from callus material—a mass of cells developing without organization. Any number of clones can be grown from a small mass of callus in tissue culture. Presently palm trees come from offshoots or "suckers" from desirable trees, but a tree produces only a few offshoots during its lifetime.

Tisserat had the cooperation of Bernard J. Finkle, ARS chemist, who is a leading authority on the use of cryogenics on plant material. Finkle is located at the ARS Western Regional Research Center, Albany, Calif.

Oversimplified, the process is like this: the callus is treated with a cryoprotectant (which aids in the freezing and thawing of the culture). The culture is then frozen using a temperature-programmed freezer to -22°F, exposed to liquid nitrogen at -321°F, and then stored in a tube above the surface of liquid nitrogen. It is kept at that temperature for hours,

(Photo courtesy of Grant Heilman.)

days, weeks, months or decades. When it is ready for re-use, it is thawed and grown into plantlets.

The researchers had similar results when they froze the tissue cultures to +5°, -4.4°, and -22°F.

Controlled freezing and deep frozen storage have been successfully applied to tissue cultures of a number of crop and ornamental plants including carrot, tobacco, sugarcane, alfalfa, rice, and now date palm. The technique has also been applied to growing points and buds of carnation, potato, pea, and strawberry.

This research was conducted while Brent Tisserat was located at the U.S. Date and Citrus Station, Indio, Calif., but he presently works at the Fruit and Vegetable Chemistry Laboratory, 263 S. Chester Ave., Pasadena, CA 91106.— (By Paul Dean, Oakland, Calif.)

Above: Date palm grove near Indio, Calif. Protective bags cover the clusters of ripening dates. (PN-6845)

Unraveling Mysteries of the Corn Rootworm

Entomologist Vernon M. Kirk shades a nylon-screened field cage used to study corn rootworm beetles' egg-laying habits. (0981X1124-25a)

On a warm night in late August in a South Dakota corn field, an egg-laden corn rootworm beetle searched for a moist underground place to cache her eggs until hatch the next spring. Because she could not have burrowed her own way into the soil, even if it had been loose, she chose a drought crack as her passageway.

This beetle was one of about a thousand that ARS entomologist Vernon M. Kirk had put into a nylon-screen field cage, 2 by 3 feet.

Kirk also studies the oviposition, or egg-laying, habits of western and northern corn rootworms in the field in a plexiglass-lined observation pit that he designed. From inside the dark pit he spies on the little creatures for hours on end with the aid of a tiny flashlight beam and a 14-power hand lens.

The scientist's studies at the Northern Grain Insects Research Laboratory, Brookings, S. Dak., are part of a team effort to develop techniques for predicting the severity of future corn rootworm infestations.

Predictions may help farmers reduce insecticide usage by allowing them to apply control measures only when and where they are needed. More effective predictions and controls could save Corn Belt farmers millions of dollars each year in reduced insecticide costs and corn yield losses.

Meanwhile, back in the corn field, just a few yards from where the caged rootworm beetle oviposited eggs in a drought crack, another cage had been placed over more moist soil. Beetles in that cage found a number of 2- to 3-millimeter (mm)-wide earthworm burrows which they could enter to oviposit.

"The densities of earthworm populations often vary greatly within fields as soil conditions vary," says Kirk. "It just may be that sometimes spotty rootworm damage in a field results from heavy rootworm oviposition in small areas riddled with earthworm burrows during a time when there is enough moisture to prevent drought cracks."

A better understanding awaits further research.

"By learning the ways of beetles in the field, we should be able to improve our ability to predict rootworm infestations," the scientist says. "Closely observing the pests also may lead to new insights on controls."

Kirk has never caught a female rootworm beetle entering an earthworm burrow, but he's seen plenty of evidence. He's taken 5- to 15-centimeter (cm) cubes of soil containing burrows and carefully picked them apart to examine the contents. He has found many beetle eggs and both living and dead rootworm beetles in burrows

Above: The grain on this ear of corn failed to develop because adult corn rootworm beetles disrupted pollination by eating the corn silk. Beetle larvae also damage the crop by feeding on the plant root system. (0981X1124-35a)

Below: Adult corn rootworm beetle. (PN-6842)

that were plugged by earthworm casts at the entrances.

He wonders why and how it all happens.

A female beetle may enter the burrow at night after an earthworm has opened it up and temporarily retreated to its depths. Maybe she even makes contact with the earthworm while it is partly out of its burrow, stimulates it to retreat, and then follows it into the burrow.

Kirk says that dead beetles he found in earthworm burrows apparently got stuck in the narrow passageways before they died. Then earthworms fed on the beetles. He's seen no signs that the earthworms bother the eggs, though.

In the laboratory he has seen the ground beetle, *Pterostichus chalcites,* voraciously eat eggs of western corn rootworms and the beetle also has captured and devoured active rootworm larvae and adults. But so far. he's seen no evidence of any species of ground beetles effectively controlling corn rootworm populations in the field.

Another drama that he has seen only in the field observation kit is ovipositing. Here's how he describes the event.

"The western corn rootworm beetle descended into the simulated crack until, at 13.5 cm below the soil surface, she was loosely wedged between the soil and the plexiglass. She oriented herself head up and probed a 0.75-mm-wide vertical hairline crack and the soil within about 2 mm with her ovipositor for 8 minutes. She then put the tip of her ovipositor into the crack, paused about 20 seconds, and extruded an egg. After another 60 seconds in the same position, she extruded another egg just below the first one. The two eggs were about 0.5 mm from the edge of the crack, horizontal and touching. Again she remained in position, but after about 30 seconds another female blundered into her and she moved away."

Oh well, that's life.

Kirk has found as many as 961 eggs hidden in a gallery off a main earthworm burrow where the worm apparently had found a volume of soil mixed with organic matter, ingested it, and moved on. Typically, rootworm females produce about 500 eggs in a season.

In the field, the researcher has found eggs of both western and northern corn rootworms in earthworm burrows and drought cracks where many kinds of weeds and crops have grown, as well as where the soil was almost bare. Evidently the females are interested only in finding moist oviposition sites underground, regardless of whether food is available there and regardless of whether prospects are good for suitable host plants for the larvae the next year, he says.

These observations may provide clues as to why scientists' attempts to predict damaging infestations have often been unsuccessful. Predicted damage sometimes fails to occur, and many fields thought to be safe from injury are severely damaged.

More effective predictions could be a boon to agriculture. They would help farmers know when to and when not to rotate their crop or apply insecticides.

"If the 20 million acres treated for corn rootworms in the United States could be reduced to 1 million acres, a minimal savings of $95 million in chemical controls could be obtained in 1 year," the scientist says.

Vernon Kirk is located at the USDA-ARS Northern Grain Insects Research Laboratory, RR3, Brookings, SD 57006.—(By Ben Hardin, Peoria, Ill.)

Southern Rust and Corn Maturity

Although southern rust has been recognized for over 100 years, it is still a potentially serious problem because available U.S. corn hybrids show little or no resistance to the disease.

ARS scientists at Mississippi State University recently studied rust severity on leaves of susceptible corn progressively during the season and on plants having staggered planting dates. Susceptibility of lower leaves to rust was not significantly affected by the maturity of the plant. Rust severity was generally delayed somewhat in upper leaves, but the researchers believe that something besides natural resistance may have caused the delay.

Beginning in May 1976, research plant pathologist Stanley B. King and research agronomist Gene E. Scott studied rust development on two southern rust-susceptible corn hybrids planted at nine weekly intervals. They found no rust in plots before August, and ratings August 6 revealed only trace amounts of the disease. However, the rust became progressively worse until the final evaluation on September 16.

"As a general rule," says King, "severity of southern rust on any given date was in part related to the level of the canopy in which leaves were located, with lower leaves having the most rust and upper leaves having the least." The severity of rust on any given day and within a given part of the canopy, however, was about the same, regardless of planting date, he adds.

King maintains that if plant maturity had much influence on susceptibility, the first planting would reach a given disease level first and the last planting last.

In 1978, King and Scott used four biweekly plantings instead of weekly plantings. As in 1976, susceptibility to southern rust apparently did not depend on host maturity. Rust first appeared the last week of July, and severity generally increased through mid-September. Earlier plantings escaped disease until late in plant development, and later plantings became diseased earlier in plant development. King reports that this was especially apparent in the lower leaves and the ear leaf.

King and Scott say that, according to their data, corn does not seem to become more susceptible to southern rust after silking. For leaves higher up in the canopy, they did find evidence for some delay in disease development, but they feel that resistance is probably not the reason.

Before silking, new corn leaves are continually expanding and emerging at the plant apex. Because southern rust takes 9 to 12 days from infection to pustule rupture, the top leaves of a plant have relatively less time for disease development than the lower leaves, where rust could recycle several times while new leaves are forming higher on the plant.

King cautioned that casual observations of rust severity on plants of different ages in adjacent rows could be influenced most by leaves at or just below eye level. Hence, he said, "In a row that has reached tasseling, evaluations are likely to be based on leaves at ear level or below, leaves that are likely to have the most rust according to our study, while a row that is several weeks before tasseling is likely to be evaluated primarily on leaves in the upper part of the plant, leaves that are likely to have the least rust."

Another rust of corn, common rust, also occurs in the United States. In contrast to common rust, southern rust has smaller, more circular pustules that are more orange in color. Also, southern rust is usually first found later in the season. But the most important difference is that southern rust can prematurely kill the corn plant, thereby often reducing grain yields, especially in late-planted corn. In some experiments, King and Scott found that southern rust reduced grain yield nearly 50 percent.

In working with southern rust, King and Scott have also been involved in the identification of resistant corn genotypes and the determination of genes causing resistance. These investigations are conducted with seedling plants in the greenhouse or with more mature plants in the field. In either case, artificial inoculation techniques are employed to ensure a heavy, uniform infection on all plants being evaluated.

Stanley B. King and Gene E. Scott are located at the Crop Science and Engineering Research Laboratory, P.O. Box 5367, Mississippi State, MS 39762.—(By Neal Duncan, New Orleans, La.)

Forcing Iris to Flower

A new technique for forcing iris bulbs to flower succeeds nearly 100 percent of the time when small bulbs, dug up as early as possible, are used. This represents a 25-percent improvement over the flowering rate achieved by the standard forcing method, according to the new technique's developer, ARS plant physiologist Robert P. Doss, Puyallup, Wash.

Iris production in the United States is a multimillion dollar industry. As a world producer, the United States is second only to the Netherlands, and virtually all of the U.S. iris crop is produced in western Washington. To maximize the number of flowers available for the market, iris bulbs are removed early from the ground and "forced," or artificially brought to flower.

Currently, iris are forced by storing fresh-dug bulbs under three successive temperature conditions: high (90°F), moderate (68°F), and low (50°F) before placing them in a greenhouse. With this process, bulbs dug up from mid-July to mid-August can be forced to flower for Christmas.

The key to the success of Doss's technique is the amount of time spent in high temperature storage. The standard forcing procedure calls for bulbs to be stored in high temperatures for 10 to 14 days, moderate temperatures for about 3 weeks, and low temperatures for about 6 weeks. Under Doss's technique, bulbs are stored in high temperatures for as long as 4 weeks, moderate temperatures 2 weeks, and low temperatures 6 weeks.

"With earlier digging and smaller bulbs, the advantage of the new technique is quite apparent," says Doss. Under his method, bulbs can be dug up several weeks early, and they are about one-half of an inch smaller in circumference than those generally used. These two factors, plus the nearly 100-percent rate of flowering, should make the method quite attractive to growers. Doss adds that for the larger bulbs dug later, the differences in flowering rates between the standard forcing technique and his are less pronounced.

Doss has also examined the fertilizer requirements for successfully forcing iris bulbs. He has found that if iris bulbs are forced in a fertile soil or in well-formulated synthetic growing mix, nutritional requirements of the plants should be met.

However, if bulbs are forced in sand, pea gravel or other infertile medium, it's essential that adequate supplies of nitrogen, calcium, and boron be added.

Robert Doss is located at the Western Washington Research and Extension Center, Puyallup, WA 98371.—(By Lynn Yarris, Oakland, Calif.)

Iris pumila, although not a bulbous iris, reflects the welcome spring beauty of the forced irises found at florists' shops during cold winter months. (Photo courtesy of Grant Heilman.)

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Agrisearch Notes

Sex Attractant Draws Lesser Peachtree Borers

Five years of testing synthetic sex attractants for the lesser peachtree borer have shown that the chemicals entice males to traps well enough to enable fruit growers to monitor borer populations in their orchards.

David K. Reed, research entomologist at the ARS Fruit and Vegetable Insects Research Laboratory, Vincennes, Ind., compared virgin female borers as bait with baits made from various blends of the major components of the sex pheromones. He says the tests showed that the higher concentrations of the pheromones lured male borers nearly as well as traps containing female borers.

The synthetic material is much cheaper and easier to use. The attractant can be replaced in the traps monthly; females must be replaced three times a week, and colonies must be maintained to supply the females.

The lesser peachtree borer is one of the most damaging pests of peaches in the Midwest and South, Reed says. The larvae feed on the inner bark of peach, cherry and plum trees, causing damaged areas that may then be invaded easily by fungi and other insects. Damage often girdles limbs and trunks, killing trees or reducing production so much that trees have to be replaced.

The synthetic attractants were developed by another ARS researcher, J.H. Tumlinson, of USDA's Insect Attractants, Behavior and Basic Biology Research Laboratory, Gainesville, Fla.

David Reed is located at the Fruit and Vegetable Insects Research Laboratory, 1118 Chestnut Street, P.O. Box 944, Vincennes, IN 47591.—(By Ray Pierce, Peoria, Ill.)

Green Ash and Hackberry Make Good Windbreaks

Green ash and hackberry are better choices than American or Siberian elm for windbreak plantings. They compete less with crops for water.

Albert B. Frank, ARS plant physiologist at the Northern Great Plains Research Center, Mandan, N. Dak., measured the water use and leaf water potential of the four windbreak species from June through late summer. He checked soil moisture conditions to 10-foot depths around the trees in research plantings made at the center in 1941.

"Green ash and hackberry drop their leaves and go into an early dormancy when the soil dries up in late summer, as it usually does in the central and northern plains," Frank says. "The two elms, however, will hold their leaves, and if rainfall occurs and soil moisture levels improve, will resume transpiration and use water which might otherwise be available for nearby crops."

Frank says results of his research suggest that earlier dormancy of green ash and hackberry not only saves water for crop use but also indicates stronger winter hardiness than the elms.

"Early leaf drop appears to be a desirable trait in plants used for windbreaks adjacent to crops," Frank adds.

Albert Frank is located at the Northern Great Plains Research Center, P.O. Box 459, Mandan, ND 58554.—(By Ray Pierce, Peoria, Ill.)